A case study of Akbarpur Sugar mill

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Abstract

India has emerged as one of the largest production of sugarcane and sugar in the world with highest number of sugar factories. In other countries sugar is a by-product, but in India sugar is the main product produced by sugar mills. India is producing large quantity of sugar because of our own needs, but now a day's only sugar production is not profitable for sugar mills. Sugar industry needs to increase their capacity in by products like alcohol, ethanol co-generation etc. In India, Uttar Pradesh and Maharashtra are one of the major sugars producing State in the country. Major sugar producing states are Uttar Pradesh (36%), Maharashtra (24%), Karnataka (11%), Tamilnadu (11%), Gujrat (4%), Andhra Pradesh (5%), Bihar (3%), Utrakhand (2%), Haryana (2%), and Punjab (2%). Total sugar production is 100000 quintal and recovery rate is 11%. Total cost of operation is 9677 lakh rupees. Total profit is 5677 lakh rupees. Current price of sugarcane is 325 rupees per quintal.

Keywords: Sugar, Sugarcane juice, Expeller, Crystals of sugar and evaporators.

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Introduction

India has emerged as one of the largest production of sugarcane and sugar in the world with highest number of sugar factories. In India, Uttar Pradesh and Maharashtra are one of the major sugars producing State in the country and in Maharashtra; Kolhapur District in particular, became a potential sugarcane belt area. Sugarcane occupies an important place in the economy of the district it is the most important cash crop of the District.

Sugarcane in as agri-energy crop and India is the homeland of these crops. India is one of the largest producer and consumer of sugar in the world. Sugar industry is the second major agro based industry of our country next only to cotton industry, which can generate prosperity in rural area through increasing employment and income. These generated income and employment have multiplier effect and helps in over all development of the country. Indian sugar industry is an important and big share in

agriculture processing industry. It has very strong impact on our rural development and provides successful rural economy. In our country nearly 50 million farmers provide employment. The Indian sugar mills currently has 527 operational sugar mills out of that 234 are in cooperative sector. Total sugar production in India 243 lakh tones out of 108.55 lakh tones in co-operative sector in the year 2010-11 also total sugar production in the year 2011-12 was 262 lakh tones and also sugar production in the year 2012-13 are 250 lakh tones, estimated production in the year 2013-14 were 237 lakh tones (Table 1). The sugarcane is grown in 21 various states of India. Mainly sugarcane mills are operating in large sugarcane growing areas like Maharashtra, Gujarat, Tamilnadu, Karnataka and Uttar Pradesh (Fig. 1). In Maharashtra alone is producing 30% of national sugar on put and maximum number of sugar mills are also in Maharashtra compared to other states in India. In the year of 2011-12 sugar factory

crushing season, 118-co-operative and 51-private sugar factories have crushed the sugarcane and the total sugar production of 90th Lakh tones and in the year 2012-13 sugar produced 70.44lakh tones in Maharashtra State. The experience of some of the progressive co-operative sugar factories, particularly those located in the State of Maharashtra in setting up and running the industries based on the by-products of the sugar industries have proved the multifarious advantages of such industries. The main by-products of the sugar industry are bagasse and molasses. By setting up industries to the first in state, it has been proved that waste materials can also be converted into wealth by adopting suitable technologies. In the second way, such industries create more employment opportunities in the rural parts of the country. Where the sugar factories are usually located such industries improve the economic status of thousand of sugarcane growers and the overall financial viability of the sugar factories there by making the working of the sugar factories much more successful. With the gradual decline in prices of sugar in India and increase

in cost of production of sugar, the working of many sugar factories is not comfortable. Therefore this is the right time to launch some by-product industry, to make the sugar industry financially viable. The dynamic leadership given by some progressive co-operative sugar factories in this direction has encouraged many more co-operative sugar factories to set up such by-product industries.

In other countries sugar is a by-product, but in India sugar is the main product produced by sugar mills. India is producing large quantity of sugar because of our own needs, but now a day's only sugar production is not production is not profitable for sugar mills. Sugar industry needs to increase their capacity in by products like alcohol, ethanol co-generation etc. This could be possible only through fuller and better utilization of the by-products and alternative produce, so that the higher value products are manufactured from them and sugar industry derives maximum benefit from the sugar crop. The ultimate prosperity of the Indian sugar industry depends upon diversification into numerous avenues based on the by-products of the sugar industry.

Table 1: Sugar production in India

Year	Sugar production (mt)
2009-10	2923
2010-11	3424
2011-12	3538
2012-13	3544
2013-14	3456
2014-15	3668
2015-16	3369

Materials and Methods

Sugar mill specification (Fig. 2)

Feed Section (Delivery, Unloading, weighing & Handling of Cane): Raw material (sugar cane) is imported and weighed on weight

Fig.1: Percentage share of sugar production in India

balance. Then it is introduced onto the feeding table by elevating the trawler through jack.

Feed table: There are four Feed tables in the industry. The purpose of feed table is to transfer the sugar cane on the cane carrier. Conveyer belts and impellers are mounted on

the feed table. They help in transportation of cane from feed point to cane carrier.

Cane Carrier: The Cane Carrier is a moving apron. Cane carrier is a type of conveyer belt which carries cane from feed table and transport it towards leveller, cutters, leveller, magnetic separator, shredder, mills, boilers, and finally to bagasse storage point. It consists majorly of two portion stated as following:

- **The horizontal portion:** It is used for horizontal transportation of cane.
- **The inclined portion:** It conveys cane horizontally as well as vertically simultaneously. Cane carrier is driven through electric motor. As this is essentially a constant-speed machine, and the carrier speed must be frequently varied, the drive is affected by a variable speed coupler.

Leveller: Leveller is a set of knives which evens out the layer of cane, so that other size reduction operations can easily be performed. The leveller blades, which are coated with specific material which are inert to cane juice, mounted on the shaft which rotates at a specific rpm. The shaft is driven through electric motor. After passing through the leveller the cane would be at such a level that can easily be handled in cutters without jamming it. There are two levellers in the sugar industry one is used before cutters and other one is used after cutters.

Cutters: Cutters are used to cut the cane into small pieces. Three cutters are installed over the feed carrier. Two of the cutters are motor driven and third one is driven through steam turbine. The knives are mounted on the shaft spindle. Different number of knives is used to make the cutting more effective.

Magnetic Separator: Magnetic separator is used to remove the iron particles or pieces which become the part of cutter cane or other iron particles which are already present. The commonest objects are: pieces of knife blades, sling hooks, broken pieces of slings, monkey wrenches, horse shoes, bolts and nuts. If iron pieces are not removed then they jam the mills

and pressure feeder, and so it is required to remove them before cane feeding to mills. Mills are very expensive due to the mill rollers.

Shredder: The objective of shredder is to complete the preparation and disintegration of the cane, so as to facilitate the extraction of juice by the mills. Shredder is a type of hammer mill which is used to disintegrate the cane. It is driven by steam turbine imported from Germany. It receives the cane from the leveller, which is placed after the third cutter and sends it to the milling house. The cane is hammered by the hammers mounted on the rod, which is inserted into the disk holes. These hammers are mounted alternatively. These hammers disintegrate the cane against a curved metal plate. After shredding this cane is passed to the milling section by shredded cane elevator.

Turbines: It is a device which is used to convert the pressure energy of the superheated steam into mechanical work. It is basically a type of prime mover. In the feed section two turbines are used. One is used to drive cutter-3 and other one is used to drive shredder. The turbine specifications are stated below.

- Turbine for Cutter-3 Turbine for Shredder
- Power 650 kW Power 1800 kW
- Inlet Steam Temperature 330°C
- Inlet Steam Pressure 22 kgf/cm²
- Outlet Steam Pressure 1.15 kgf/cm²

Mills: Mill is a machine which is used to extract the juice from shredded cane. It consists of two major parts:

(a) Pressure Feeder: Pressure feeder consists of three rolls stacked together to form a shape of triangle and its lower roller is driven through steam turbine. Objective of pressure feeder is to feed the shredded cane at high pressure to the mill inlet in order to facilitate the cane milling operation for proper juice extraction and in order to avoid shredded cane back coming effect.

(b) Mill: Mill itself also consists of three rolls for juice extraction. The rolls of a mill are stacked together to form a triangle shape and its upper roller is driven through steam turbine. Objective of a mill is to extract the juice from shredded cane. In reality pressure feeder and mill both are integrated to each other in order to form a six roll stack for easier cane handling. There are five mills are used in series, each mill have a pressure feeder associated with it. About 80% juice is extracted in mill-1. Feed to each pressure feeder is introduced by inclined cane carrier. So every mill's pressure feeder has an inclined cane carrier associated with it and it proceeds to mill.

Trace Plate: Trash plate is a plate with teethes on both sides and it is used among mill rollers. It fulfils two basic functions:

- It provides a tight fitting between rollers which improves the crushing and so juice recovery is improved.
- Its teeth clarify the space between roller disks to some extent which prevent mill choking.

Clarifier (Sedimentation): The main purpose of the clarifier is to clarify the juice by removing impurities in the form of mud. Hot juice enters into the clarifier by four paths that combines in the feed launder. Then after the filling of the feed launder it falls inside the channel to depletion plate. The purpose of the depletion plate is to minimize the splashing effect which causes mud disturbance. Splashing causes to break the mud cake at the bottom of the clarifier due to this mud disturbance it may come in the juice again and so clarification will not give clarified juice, so we have to prevent splashing by depletion plate. Impurities are converted into mud by the addition of a suitable polyelectrolyte. This polyelectrolyte having high molecular weight attaches impurities with it and form strong bond with them which causes the formation of mud. This mud having high density starts to fall under the action of

gravity to the bottom of the clarifier which is known as sedimentation, and this is the basic concept which governs this type of clarification. The polyelectrolyte in the form of solution is supplied to four juice supply distribution drums, where it is mixed in a certain proportion with hot juice feed which goes into feed launder. This polyelectrolyte solution in water is made prior to clarification in a vessel by simple mixing effect. The level of juice raises in the clarification tank and reaches to the inside and outside launders. Juice enters into these two launders and then with the help of their separate outlet pipes combine into a compartment of the outlet supply drums. It attains a level in the compartment and then enters into the second compartment of the outlet supply drum from which it is supplied to the DSM screens. There are three DSM screens used in the industry with 0.35mm screen size. The juice is then sent to juice pre heater where its temperature is increased to 110°C ~ 115°C. The mud is removed from the bottom of the clarifier tank with the help of the scraper and is sent to the Mud mixer. There are two clarifiers used in the sugar mill. In first clarifier the depletion plate has conical upper surface. The height and diameter of first clarifier are 6m and 9.15m respectively. Second clarifier is of SRI type. In the second clarifier the upper surface of depletion plate is flat. And in the second clarifier mud scraper also translate itself for better mud removal. The length and diameter of second clarifier are 3m and 8m respectively. Only one clarifier operates in the season during production. The temperature inside the clarification tank is kept to 105°C.

Evaporators: Evaporator is equipment that is used to concentrate the solution by evaporating the solvent (water). There are two types of evaporators are used in the industry as follows:

- Falling film evaporator (FFE)
- Multiple Effect Evaporator (MEE)

Multiple Effect Evaporators: It is also a type of shell and tube heat exchanger. In this evaporator vapours or steam which is used for

first effect as a heating media will condense and the vapours produced by evaporation of solution will be used in next effect as heating media, while the same solution is evaporated in multiple effects. This Process repeats in the remaining effects. Such types of ten effects are installed in the industry while five of them works for the produced capacity. There is a gap between the half bundles of tubes which is known as central well. The width of the central well is $\frac{1}{4}$ times of the diameter of the evaporator. Juice enters from the bottom of calandria and after heat exchange it comes back from central well. Water present in the juice is evaporated and collected from the top and is further utilized as heating media to the next evaporator. Concentrated juice is collected from the bottom and it is sent to the next body. Juice discharges as concentrated juice termed as syrup is collected from last body (evaporator). Juice enters the FFE from juice pre heater at $110^{\circ}\text{C} \sim 115^{\circ}\text{C}$, and after passing through FFE it enters into MEE which increase the Brix and converts juice to syrup. There are two FFE's are installed in the industry, one of them is in working condition. There are ten evaporators other than FFE's. These evaporators are used in multi effect. No of effects required depends upon the required heat transfer area. In usual production, five effects are used in order to get the required evaporation. At the entrance of 1st effect brix is 15, while at the outlet of 5th effect brix is 65.

Crystallizers: There are two main types of crystallizers:

- Horizontal crystallizer
- Vertical crystallizer

Horizontal Crystallizer: The crystallizer, horizontal in shape with open top side is called horizontal crystallizer. The crystallization process consists of two major events, nucleation and crystal growth. Nucleation is the step where the solute molecules dispersed in the solvent start to gather into clusters that become stable under the current operating conditions. The crystal growth is the subsequent growth of the nuclei that succeed in achieving the critical cluster size. Nucleation and growth continue to occur simultaneously while the super saturation exists. Super saturation is the driving force of the crystallization hence the rate of nucleation and growth is driven by the existing super saturation in the solution.

Vertical Crystallizer: Vertical crystallizer is used in cane sugar industry for efficient sugar crystallization from low-purity crystal suspensions.

Sugar Grader: Sugar grader is used to separate the different sizes sugar crystals for market and industrial operation demands. Particle Size of Sugar grain 4, 8, 12, 16, 20 mesh is produced as per market requirement.

Dryer: Drier is used to dry the final product sugar crystals with the help of steam.

Hopper: Hopper is used to supply the final sugar to packaging section.

Packaging: After hopper sugar is packed into 50 kg bags. Manual packaging is used and it is closed by sewing machine. In 8 hr shift 3500 bags are produced.

Table 1: Basic information about sugar production in akbarpur sugar mill

Particulars	Data
Sugarcane price payable (Rs/quintal)	325
Recovery Rate	11 %
Sugarcane price per kg of sugar produced (Rs/kg)	26.40
Conversion cost from Sugarcane to raw sugar (Rs/kg)	3.50
Total cost of raw sugar production (Rs/kg)	29.90
Conversion cost from raw to white sugar (In Rs/kg)	2.5
Total cost of production for white sugar (Rs/kg)	32.40
Domestic ex-mill sugar price (Rs/kg)	26.10-26.60

Fig.2: Flow chart of sugar mill process

Results and Discussions

Processing of sugar

The sugar process divided in the following steps. The basic information and production data of sugar production of Akbarpur sugar mill given in Table 1 & 2.

Entry or transportation of the sugar: Sugar is obtained from the cane at mills located near centers of production. The cane first goes through a washer, then is cut into small pieces by revolving knives. After this step the small pieces are shredded. The shredder is a large powerful hammer mill that shreds the cane into a fibrous material. The cells in the cane stalk containing the sugar juice are ruptured but no juice is extracted at this stage. After this

preparation, the juice from the sugar cane can be extracted.

Milling train: The shredded cane is fed through a series of crushing mills to extract the sugar rich juice, which is then pumped away for further processing. The remaining fibre is called bagasse. The crushers consist of two large grooved rollers mounted horizontally, and then one above of the others. On the upper roller heavy hydraulic pressure is maintained.

Clarification: The limed juice enters a gravitational settling tank: a clarifier. The juice travels through the clarifier at a very low superficial velocity so that the solids settle out and clear juice exits. The mud from the clarifier still contains valuable sugar so it is filtered on rotary vacuum filters where the

residual juice is extracted and the mud can be washed before discharge, producing sweet water. The juice and the sweet water are returned to process.

Evaporation: The clarified juice is concentrated to syrup by boiling off excess water in a series of connected vessels. Under automatically controlled conditions in the evaporator station, each subsequent vessel operates under decreasing pressure with the last one being under almost a total vacuum. After this step the syrup is ready to go to the high-vacuum boiling pans.

Crystallization: Concentration of the syrup from the evaporator is continued in vacuum pans. Very small seed crystals are introduced to the concentrating syrup and these begin to grow in size. When the crystals reach the required size, the mixture of crystals and syrup is discharged from the pan.

Separation: The sugar crystals are separated from the syrup in centrifugal machines that have an action similar to a spin-dryer. After leaving the centrifugals, the moist raw sugar is tumble dried in a stream of air and transferred to bulk storage bins. The separated syrup is reboiled and further sugar is crystallized. After three boiling no further

Ion exchange: The clear but tan coloured sugar solution is pumped through a series of columns containing an ion exchange resin which absorbs the remaining colour to produce a clear and colour less solution known as fine liquor.

Evaporation: Water is evaporated from the fine liquor in specially designed equipment to concentrate the sugar solution into a stream known as thick liquor.

Vacuum pan & Crystallizer: Thick liquor is transferred to boiling vessels known as pans where under controlled vacuum the liquor is boiled at low temperature to further concentrate the solution. As water evaporates and the liquor concentrates, sugar crystals begin to form, their growth being controlled by careful adjustment of the boiling conditions.

sugar can be economically removed. The residual sugar is called molasses.

Sugar refining: The purpose of the refinery is to remove impurities from sugar crystals. The refinery accepts raw sugar as its feed material. The sugar is dissolved (melted) and the colour is removed by various clarification processes. The final refining steps include melting the brown or raw sugar, decolouring by passing through carbon filters, recrystallizing in vacuum boiling pans, and drying by centrifuging.

Affination: The Affination process comprises a U-mixer, hot magma mingler, centrifugal and sugar melter. In the U-mixer raw sugar is stirred with a measured amount of water before transfer to the mingler for heating and slurring.

Carbonation: Dissolved sugar from the melter is reacted under carefully controlled conditions of pH and temperature, with milk of lime (CaO) and Carbon Dioxide (CO₂) to form a calcium carbonate (CaCO₃) precipitate.

Filtration: Carbonated liquor (solution) is pumped through a series of leaf filters which retain the calcium precipitate in the filter and discharge a clear but coloured sugar solution.

Centrifugal: Masseccuite from the crystallizers is processed through centrifugals where the spinning action separates the sugar crystals from the remaining liquid solution (molasses).

Sugar handling & Packaging: The wet crystals are discharged through a rotating drum into which hot air is continuously blown to remove moisture and dry the crystals. At the exit of the dryer the crystals are cooled and passed through a sieve to grade the crystal size. Any dust formed during this process is removed by vacuum and the sugar then conveyed to the packing area for final packing into 50kgs bags.

Cost analysis of Sugar Production in Akbarpur Sugar mill

Cost analysis of sugar production of Akbarpur Sugar mill is discussed in Table 4.

Table 2: Performance data of akbarpur chini mill

Particulars	2013-2014	2014-2015	2015-2016
Crushing Capacity (M.T.)	7500	7500	7500
Cane Crushed (Lakh M.T.)	7.06	6.34	7.14
Sugar Produced (Lakh / Qtl)	6.99	6.10	7.85
Sugar Recovery (%)	9.76	9.60	11.0
Molasses Produced (M.T.)	32017	29853	32165

Table 4: Cost analysis of Akbarpur Sugar mill

S. No.	Description	Rs. (Lakhs)
A.	Civil Work	
1.	Land Development, grading & Levelling	100.00
2.	TG Building	225.00
3.	Plant Buildings for the Fermentation Control Rooms Electrical rooms, WTP Alcohol Issue area	200.00
4.	Foundation for the complete distillery & power plant & Tanks	550.00
5.	Raw Water Tank	70.00
6.	Conveyor Foundations	90.00
7.	Road and Drain Work - Land & Site	80.00
8.	Pipe Rack Support & Cable Rack	68.40
9.	Concrete Chimney	80.00
10.	Total for Civil works	1463.40
B.	Mechanical Work	
1.	Complete distillery plant (fermentation distillation, evaporation) including Interconnecting piping, structural supports etc.	3000.00
2.	20 TPH spent wash incineration steam generator including fabric filter, fans pumps, valves and specialities, piping PRDS and other Auxiliaries.	1450.00
3.	1 x 2.2 MW back pressure turbo generator unit, including all auxiliaries, piping, governor turbovisory, controls and Instrumentation and electrical as per scope.	350.00
4.	Bagasse handing system with all its accessories.	150.00
5.	Ash handling system for the boiler consisting of submerged scrapper conveyers, for wet ash and dense phase handing system for fly ash.	120.00
6.	Induced draft cooling tower (RCC work included in civil scope).	60.00
7.	Centrifugal Pumps with base frames and electric motor drives for the cogeneration power plant.	60.00
8.	Steam, Water piping and valves & supports from the power plant. Tanks for Molasses, DM & Process water.	325.00
9.	Reverse Osmosis based water Treatment Plant.	220.00
10.	Day receiver and Bulk Storage Tanks for the products.	400.00
11.	Power House EOT Crane	30.00
12.	Air Conditioning system & Ventilation system for the TG building, MCC room & control rooms in process plant & cogen. Plant.	80.00
13.	Air Compressors for both Process and cogeneration plant.	65.00
14.	Fire Protection Systems for the process and cogeneration plant.	180.00
15.	Laboratory	28.00
16.	Weigh Bridge	25.00
17.	Condensate & Spent lees treatment and Polishing	275.00
	Total for mechanical works	6818.00

C.	Instrumentation works	
1.	Distributed Control system & Miss Instrumentation other than those covered by other packages and UPS.	225.00
2.	Balance of Plant Instrumentation.	125.00
	Total for instrumentation works	350.00
D.	Electrical works	
1.	Generator and all generator accessories including relay metering and control panels, AVR, Synchronising panel, NGR & LAVT and Switchboards.	Included in turbine
2.	Plant Electrical Package including Transformers, cables, LT Panels, VFD Panels, contract package etc.	500.00
3.	DG Set Package.	110.00
4.	Total electrical works	610.00
E.	Miscellaneous fixed assets	
1.	Furnitures for Office, WTP building office including computers, EPABX etc.	15.00
2.	Furnitures for process control rooms and office.	10.00
3.	Plant Vehicles	15.00
4.	Office Air Conditioning & Ventilation Equipment, Lighting, etc.	5.00
	Total for miscellaneous fixed assets	45.00
	TOTAL WORKS COST (A+B+C+D+E)	9286.00

F.	Calculation of interest during construction	
	Construction Period (Months)	16
	Rate Of Interest for Term Loan	12.50 %
	Rate of Interest for SDF Loan	6.50%
	Rate of Interest for Bridge Loan **	13.00 %
	Debt Equity Ratio (SDF Loan is also considered as Equity)	1
	Total interest during construction	390.91

Total cost of operation = 9286 + 390.91 = 9676.91 lakh or ~ 9677.00 lakh

Total sugar production = 100000 Quintal = 10000000 kg

Price of sugar per kg = 40 Rs

Total profit = Total cost of machine – Total production × Price of sugar

= 967700000 – 10000000 × 40

= Rs. 567700000/- or = **5677 lakh**

Conclusions

- The group member expressed satisfaction of the opportunity to visit the chini mill.
- Filled reality on operation and functional mill of huge capacity was first kind for all the group members.
- Fairly a good idea received in the collection, milling and marketing of sugar.
- Contact points for business were understood.
- Gross expenditure required for running a mill was visualized.
- Roll of middle man in sugar trading was not to be important to expand the sugar business was understood.
- Besides, field with production of sugar at the time of visit was encouraging.
- The purpose of this visit is well achieved.

The case study of Akbarpur sugari mill at Mijhaura, Ambedkarnagar was done on the

basis of data collection. On the basis of study following conclusion has been drawn.

- The cost of operation is the Rs. **9677.00 lakh.**
- The total sugar production at Akbarpur Chini mill plant during 2016 is **100000 Quintal.**
- Total profit **5677.00 lakh.**
- Recovery from 1 quintal is **11%.**
- The technologies simple that person can be trained in only two weeks to operate the chini mill.

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